

§4. Getting High-Beta Data with Peaked Density Profile for Extrapolation to FFHR-d1

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Core plasma design for the helical fusion DEMO reactor FFHR-d1 [1,2] is being carried out using the Direct Profile Extrapolation (DPE) method [3,4]. Recent analysis showed that the large Shafranov shift expected in FFHR-d1 can be mitigated by applying the vertical magnetic field control in the high aspect ratio configuration [5,6]. According to the detailed physics analysis using the profile data obtained at $R_{ax} = 3.60$ m, $B_0 = 1.5$ T, and $\gamma_c = 1.20$,

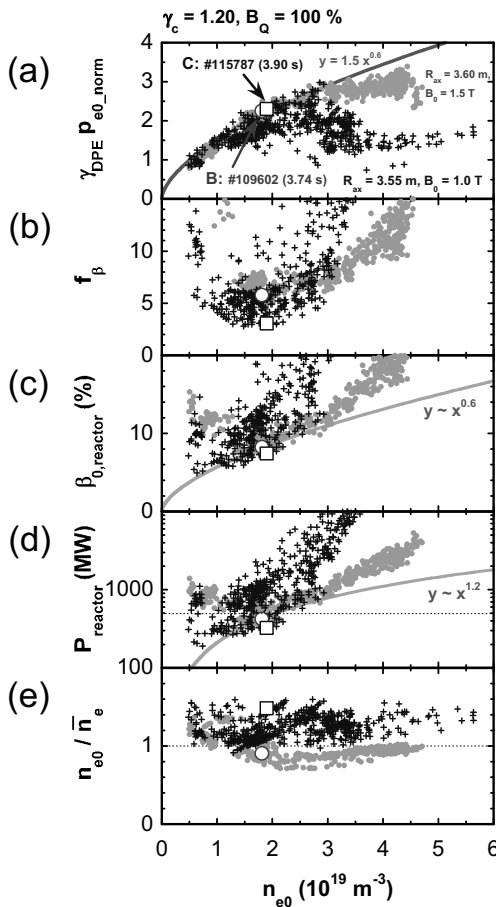


Fig. 1. Summary of the high-beta experiment in the high aspect ratio configurations of $\gamma_c = 1.20$ and $B_Q = 100\%$, where (a) the gyro-Bohm normalized central electron pressure, p_{e0_norm} , multiplied by the confinement improvement factor, γ_{DPE} , (b) the beta enhancement factor, f_β , (c) the central beta in FFHR-d1, $\beta_{0,reactor}$, (d) the conduction loss in FFHR-d1, $P_{reactor}$, and (e) the density peaking factor are shown from top to bottom. Closed circles and plusses are the data obtained at $(R_{ax}, B_0) = (3.60 \text{ m}, 1.5 \text{ T})$ and $(3.55 \text{ m}, 1.0 \text{ T})$, respectively. The open circle and the open square denote Case B and Case C, respectively. See [3,4] for more details about the parameters used here.

which is named “Case B”, the neoclassical thermal loss expected in FFHR-d1 can be reduced to a level consistent with the alpha heating power [5]. However, the density profile in Case B was hollow [6], which resulted in the broad alpha heating profile. This is inconsistent with the assumption used in the DPE method that the alpha heating profile will be centrally peaked in the reactor [4]. Therefore, the data with a peaked density profile obtained in the high aspect ratio configuration have been desired.

In the 16th cycle LHD experimental in 2012, we have tried to obtain the high-beta data with peaked density profile at a magnetic configuration of $R_{ax} = 3.55$ m, $B_0 = 1.0$ T, and $\gamma_c = 1.20$. In Fig. 1, the experimental results are compared with those obtained at $R_{ax} = 3.60$ m, $B_0 = 1.5$ T, and $\gamma_c = 1.20$. The confinement property at low-density is similar in both cases (Fig. 1(a)). The beta enhancement factor, f_β , is as low as ~ 3 in the case with $R_{ax} = 3.55$ m and $B_0 = 1.0$ T (Fig. 1(b)), presumably because of the lower B_0 that results in the higher beta in the experiment. The central beta, $\beta_{0,reactor}$, and the conduction loss, $P_{reactor}$, in the reactor condition are also similar (Figs. 1(c) and 1(d)). By applying the positive ion based neutral beam injection and the hydrogen ice pellet injection, high density peaking factors were achieved at high density of $> 2 \times 10^{19} \text{ m}^{-3}$ (Fig. 1(e)).

Finally, a set of profile data has been chosen and named “Case C”. The DPE result for the Case C is shown in Fig. 2. Detailed physics analysis for the Case C is ongoing.

- 1) A. Sagara, et al., Fusion Eng. Des. **87** (2012) 594.
- 2) T. Goto, et al., Plasma Fusion Res. **7** (2012) 2405084.
- 3) J. Miyazawa, et al., Fusion Eng. Des. **86** (2011) 2879.
- 4) J. Miyazawa, et al., Nucl. Fusion **52** (2012) 123007.
- 5) J. Miyazawa, et al., 24th IAEA FEC, FTP/P7-34.
- 6) J. Miyazawa, et al., this report.

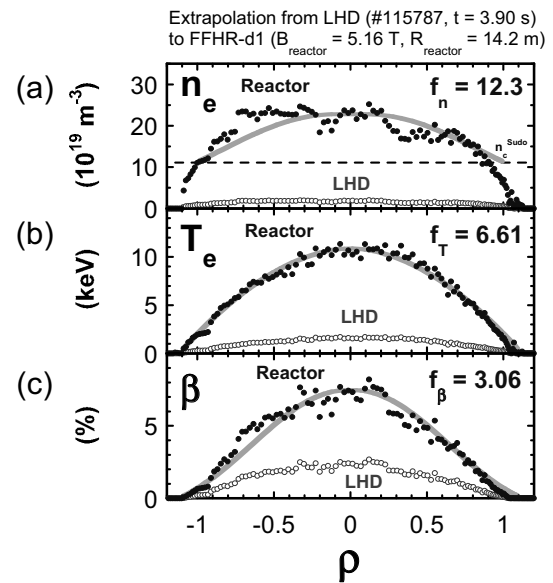


Fig. 2. Radial profiles of (a) electron density, (b) electron temperature, and (c) plasma beta, in LHD (open symbols) and FFHR-d1 (closed symbols).